

# **Update on GMAO Modeling in support of understanding stratospheric intrusions and air quality**

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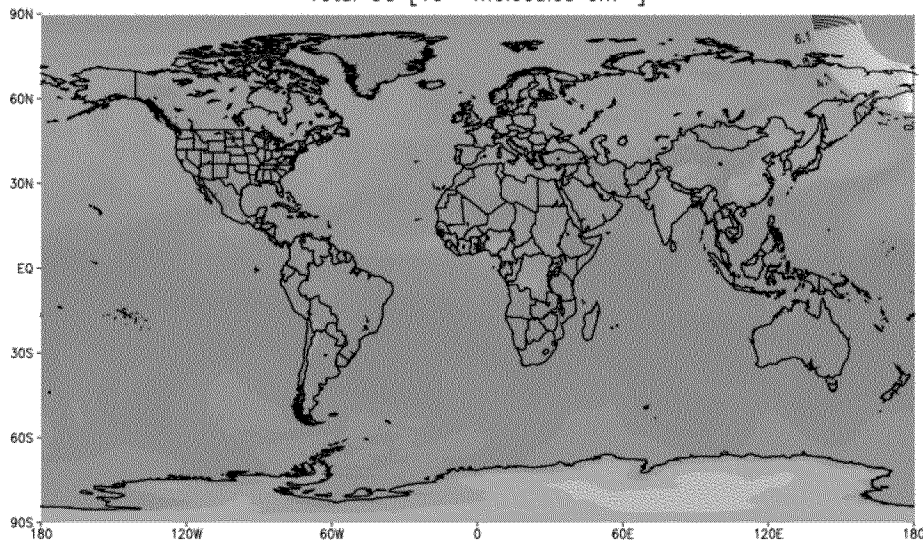
# Introduction to GMAO modeling

- Based around the GEOS-5 Earth system model
- Can be run with several different chemistry options
  - Computationally efficient: aerosols, CO, CO<sub>2</sub>, some idealized and tagged tracers
  - Greater realism but more costly: GMI or GEOS-Chem chemistry mechanisms allow simulation of complex NO<sub>x</sub>-O<sub>3</sub> photochemistry
- Run at different spatial resolutions
  - In near-real time at ~25 km
  - For retrospective analyses (MERRA, MERRA2) ~50km
  - For research simulations 25km-200km

# Near Real-Time Products

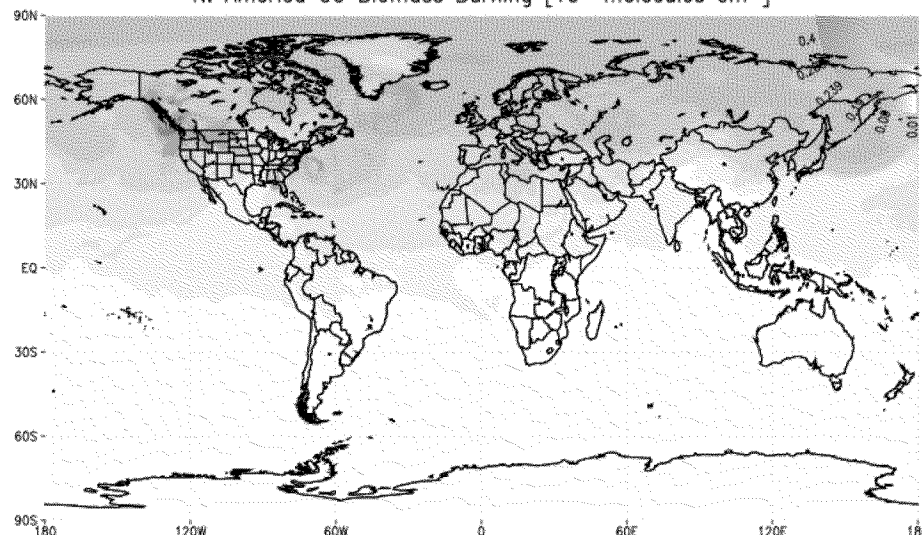
NASA/GMAO - GEOS-5 Forecast Initialized on 00z 2015-05-18

Total CO [ $10^{18}$  molecules  $\text{cm}^{-2}$ ]

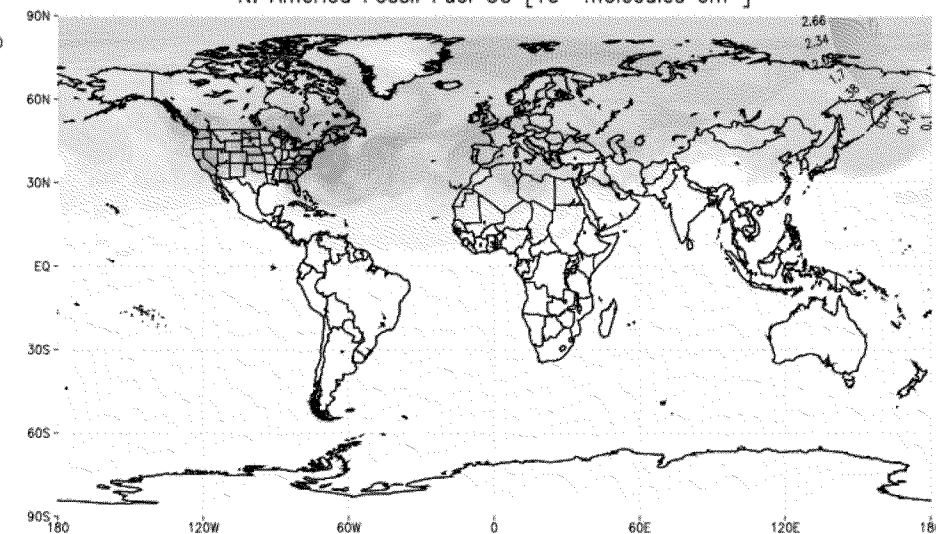


0 hr forecast valid Mon 00z 2015-05-18

N. America CO Biomass Burning [ $10^{18}$  molecules  $\text{cm}^{-2}$ ]



N. America Fossil Fuel CO [ $10^{18}$  molecules  $\text{cm}^{-2}$ ]

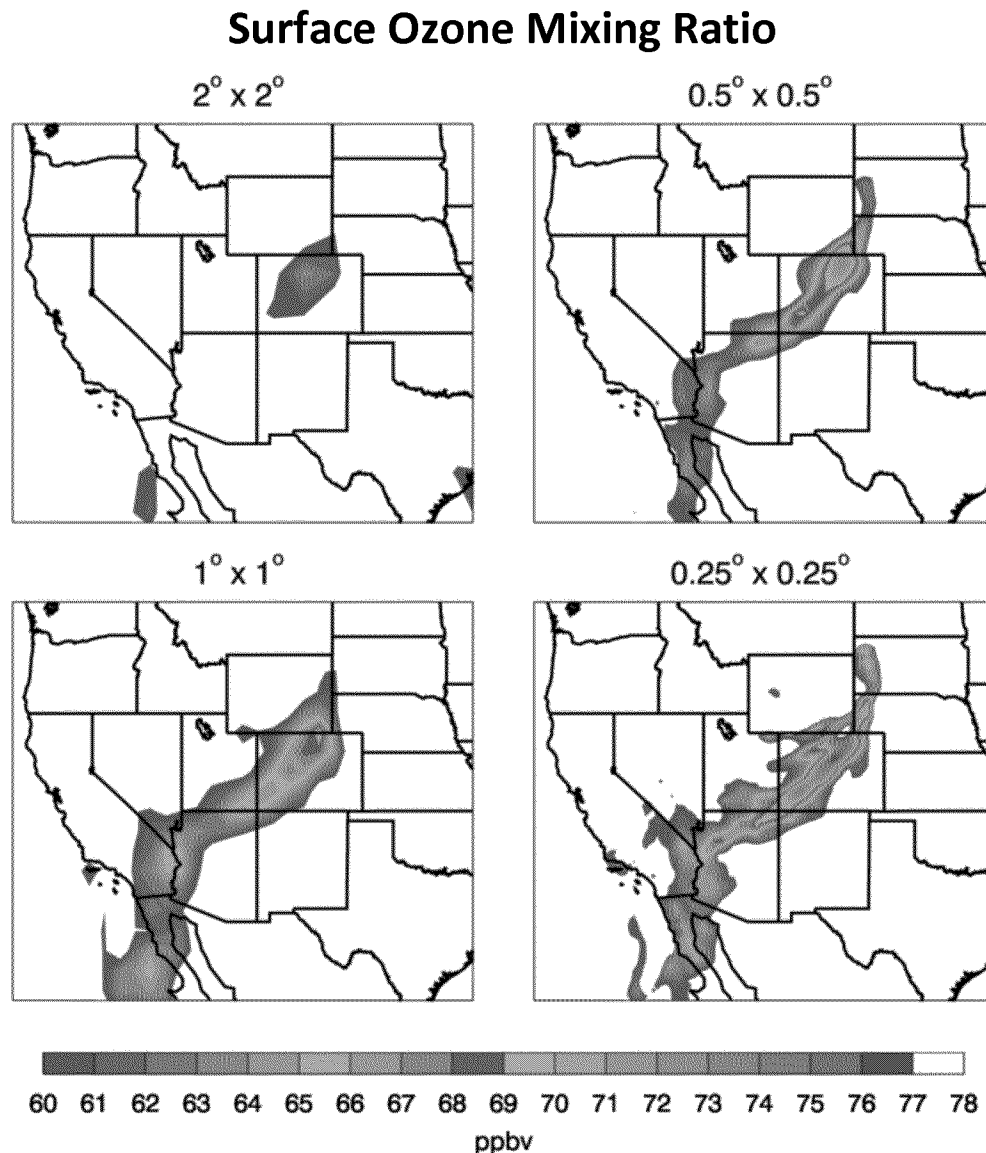


0 hr forecast valid Mon 00z 2015-05-18

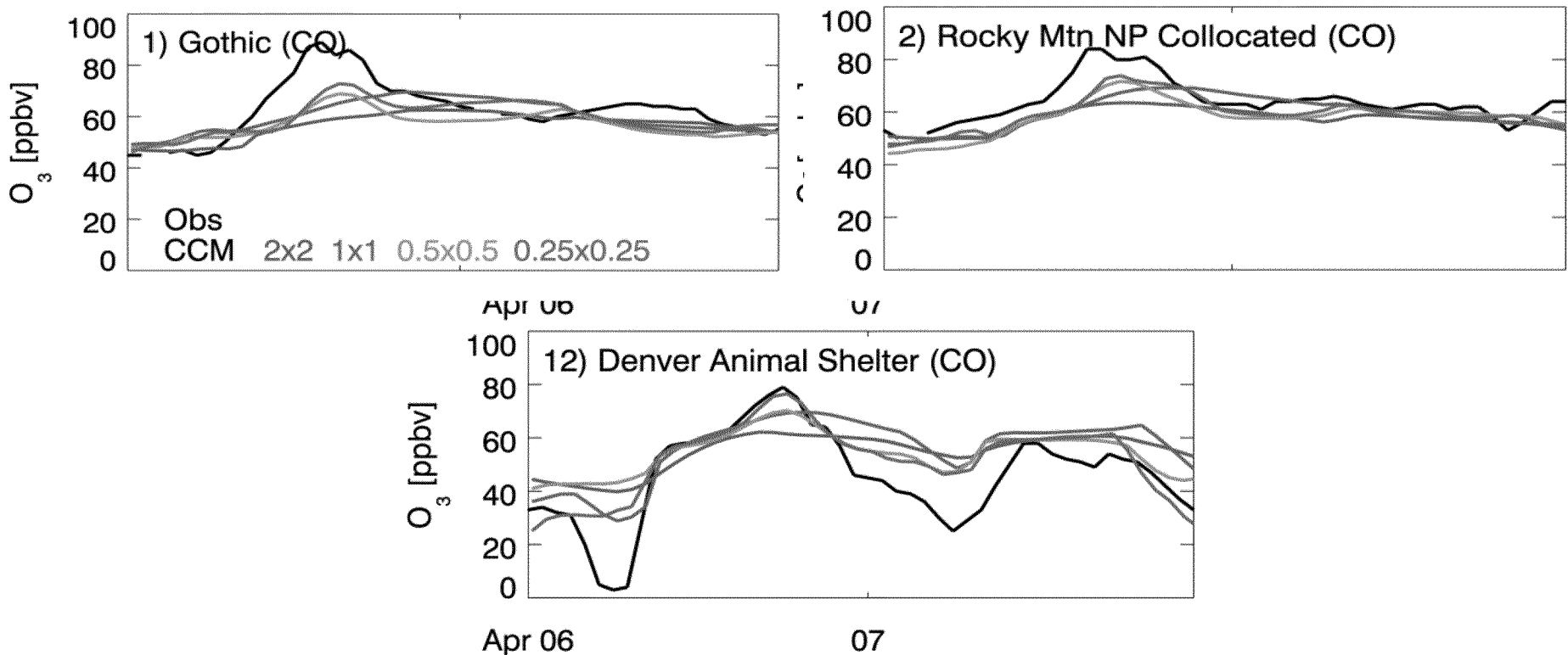
- Currently **don't** include stratospheric tracer or ozone chemistry
- **Do** include aerosols (with MODIS AOD assimilation), tagged CO tracers frequently used in forecasting for NASA field campaigns
- Near real-time fire emissions estimates using MODIS fire radiative power
- Aerosol and CO 10-day forecasts
- Available at <http://gmao.gsfc.nasa.gov/forecasts/>

# Stratospheric Intrusion Simulations

- Run retrospectively for periods of interest
- Require high spatial resolution ( $\sim 25\text{-}50\text{km}$ )
- Case study for April 6-7, 2012 where peak observed ozone at surface exceeded 80 ppbv
- GEOS-5 simulations tend to underestimate surface values, but this improves as model resolution increases

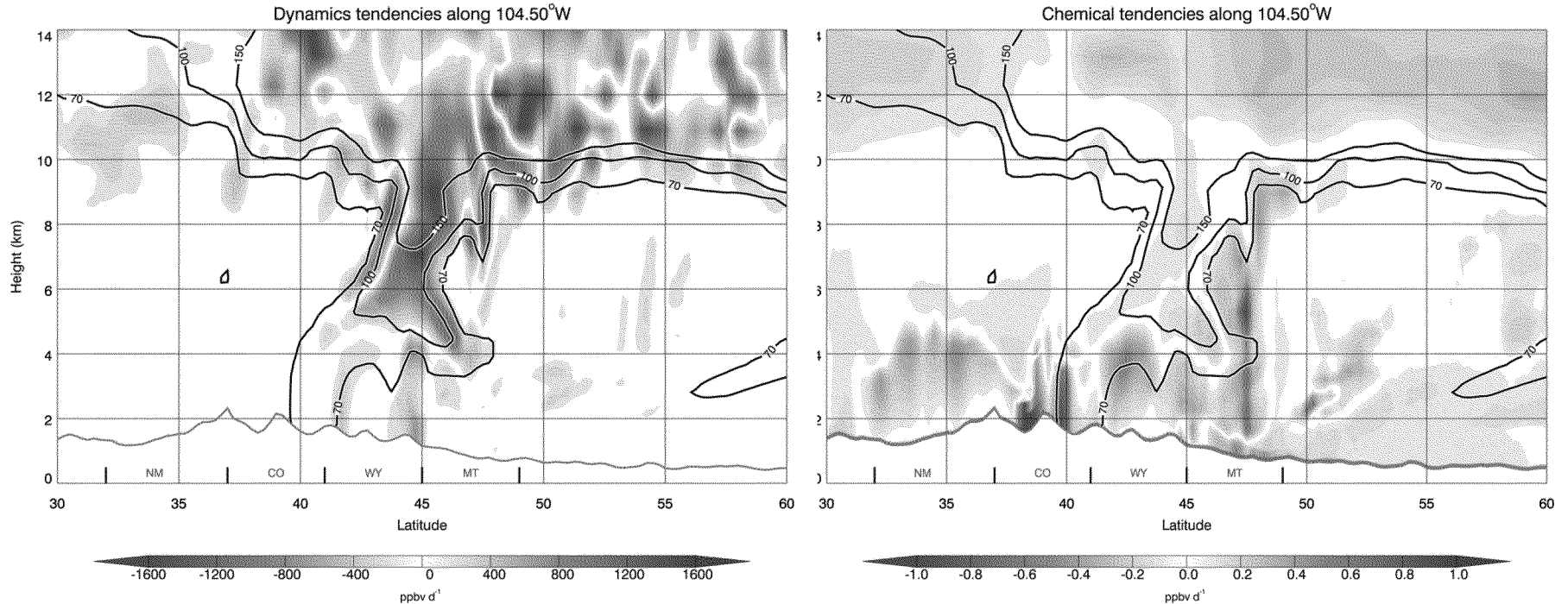


# Case Study: April 6-7, 2012



- The model generally under-predicts surface ozone, but does show skill at capturing the intrusion
- Simulating surface ozone in mountainous terrain remains a challenge for all models
- At the urban Denver Animal Shelter site, daytime max is well captured, but the model fails to simulate low ozone associated with the titration of ozone at night by fresh emissions of NO

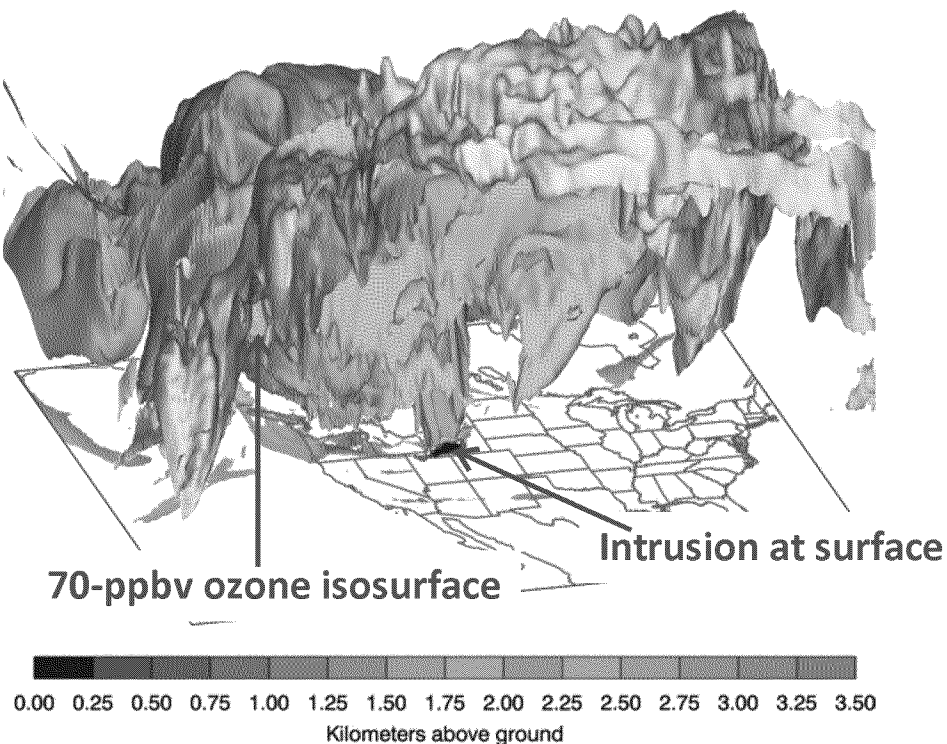
# Case Study: April 6-7, 2012



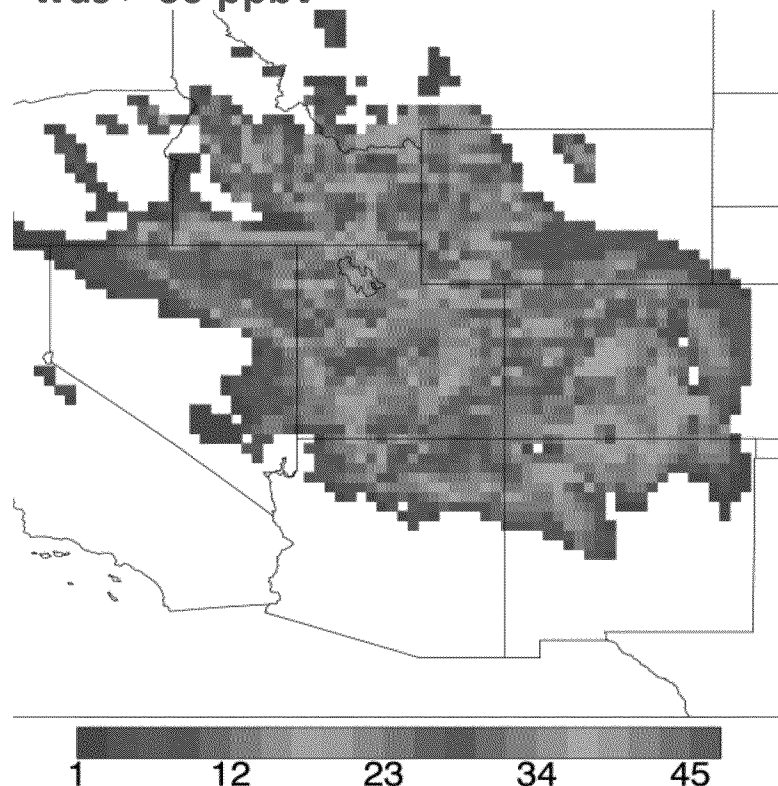
- Model tendency terms provide insight into the processes controlling ozone during intrusions
- During the April 6 intrusion, the tendency due to large-scale transport was more than 1000 times greater than chemical production/loss

# Case Study: February 27-28, 2009

GEOS-5 25x25 km<sup>2</sup> simulation of stratospheric intrusion on February 27-28, 2009

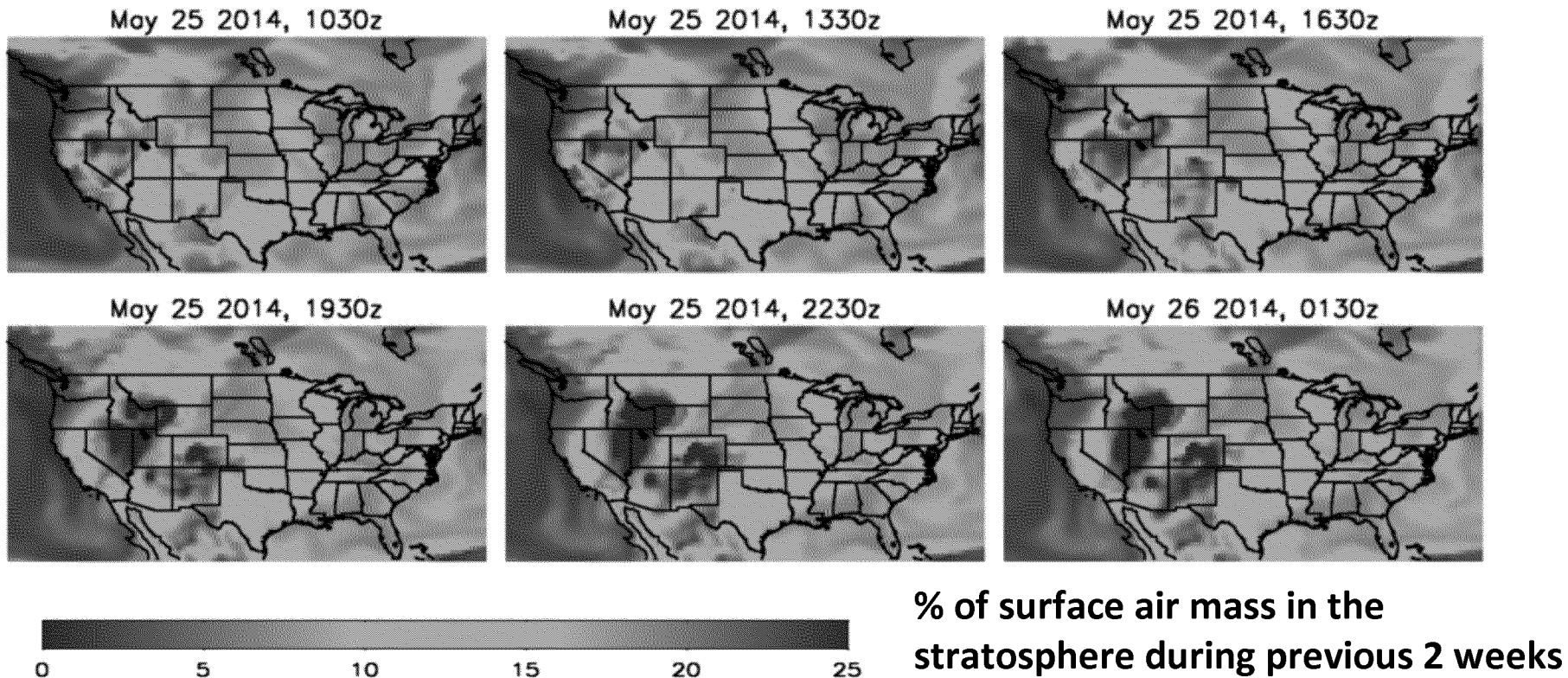


# hours the 8-hr average surface ozone was > 60 ppbv



- Simulation of 2009 event highlights the complex structure of the intrusion
- The model tends to overestimate ozone mixing ratios near the surface, but succeeds in capturing the breadth and duration of the event

# Case study: May 25-26, 2014



- Recently simulated with simple stratospheric tracers – set to 1 above tropopause for a series of 7 days
- Allow an estimate of the influence of stratospheric air and approximate age since last stratospheric contact
- Tracer shows that the influence of stratospheric air increases throughout May 25 and is widespread across the western US, Colorado early on May 26

# Conclusions and Future Work

- High-resolution global models provide a new tool for understanding the impacts of stratospheric intrusions
- Our analysis indicates resolutions of 25-50 km are needed to capture the complex structure of intrusion (consistent with Meiyun Lin and Arlene Fiore's findings)
- GEOS-5 succeeded in capturing ozone enhancements associated with April 6-7, 2012 event, but underestimated the magnitude of enhancement
- Underestimate likely related to emissions (in the process of updating) and difficulty resolving terrain
- Currently simulating April, 2015 period to examine impacts of intrusions using idealized tracers